Illicit Discharge Detection and Elimination: Field and Laboratory Assessment Protocols

Presented At:
A Workshop for Stormwater Program Managers
Salem, Oregon
September 16-17, 2004

Presentation Developed By:

CENTER FOR WATERSHED PROTECTION

Conduct Field & Lab Work to Identify Illicit Discharges

- Purpose:
  - Conduct rapid field screening to identify & track suspected outfalls & stream segments in priority subwatersheds
  - Conduct investigatory sampling & analysis to establish flow types & likely sources

- Elements:
  - Field screening
  - Field data analysis
  - Chemical monitoring

Conduct Field & Lab Work to Identify Illicit Discharges

- Desired Product or Outcome(s):
  - Locations & physical characterizations of all outfalls incorporated into tracking system
  - Strategy on how to conduct & pursue chemical analysis
  - Indicator monitoring for suspect outfalls
  - Local “fingerprint” library
- Budget and/or Staff Resources Required:
  - Extent & number of outfalls initial factor influencing level of effort
  - Extent & complexity of observed problems will dictate level of effort
  - Budget estimates based on a MS4 with 10 miles of stream & analyzing 80 samples per year range from $30,000 to $50,000

Top Problems in Identifying Inappropriate Discharge Sources

Source Related

- Periodic nature
- Illegal dumping / one-time dischargers
- Illegal connections
- Inflow/infiltration from sanitary sewers
- After-hours discharges

Infrastructure Related

- Accessibility (building, stream, outfall, traffic)
- Complexity of network
- Natural influences (tidal, groundwater)
- Size of drainage basin
- Multiple sources w/in system

Program Related

- Accuracy of mapping
- Timeliness of complaint
- Insufficient staffing
- Insufficient expertise
- Slow laboratory analysis
- Unreliable equipment
- Use of unreliable indicat

Conditions Driving Program Setup

- No Suspected Discharges
  - broader stream assessment program
- Isolated Problems
  - confined subwatersheds, reaches, or specific industries where history of suspect discharges exist
- Severe Problems
  - recognize that IDDE program will need significant commitment (staff, equipment, budget) for improvements to be realized

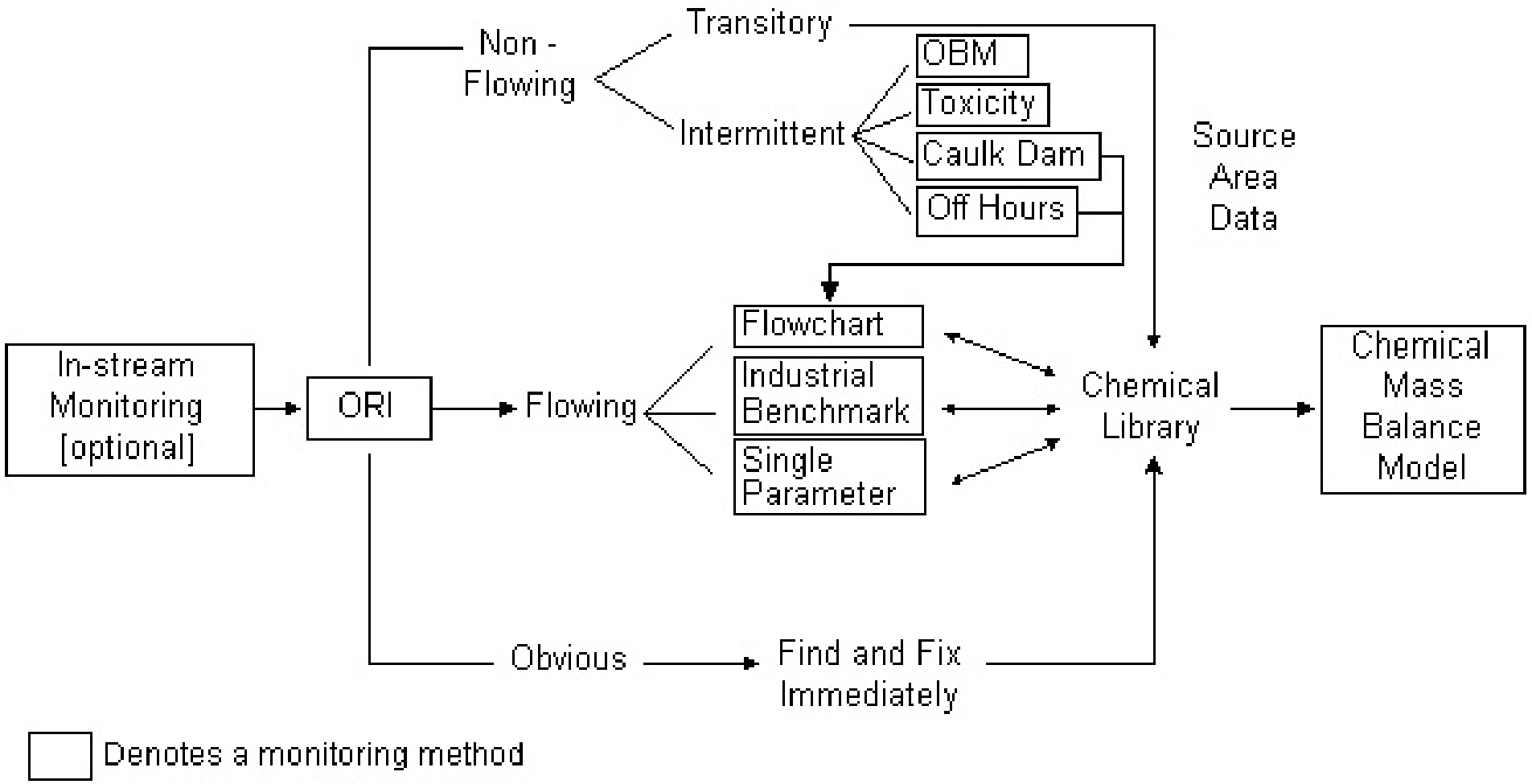
CENTER FOR WATERSHED PROTECTION

Field and Lab Protocol

1. Pre-Screening Prioritization
2. Outfall Reconnaissance Inventory (ORI)
3. Post-Screening Prioritization
4. Detailed Field Sampling / Lab Analysis

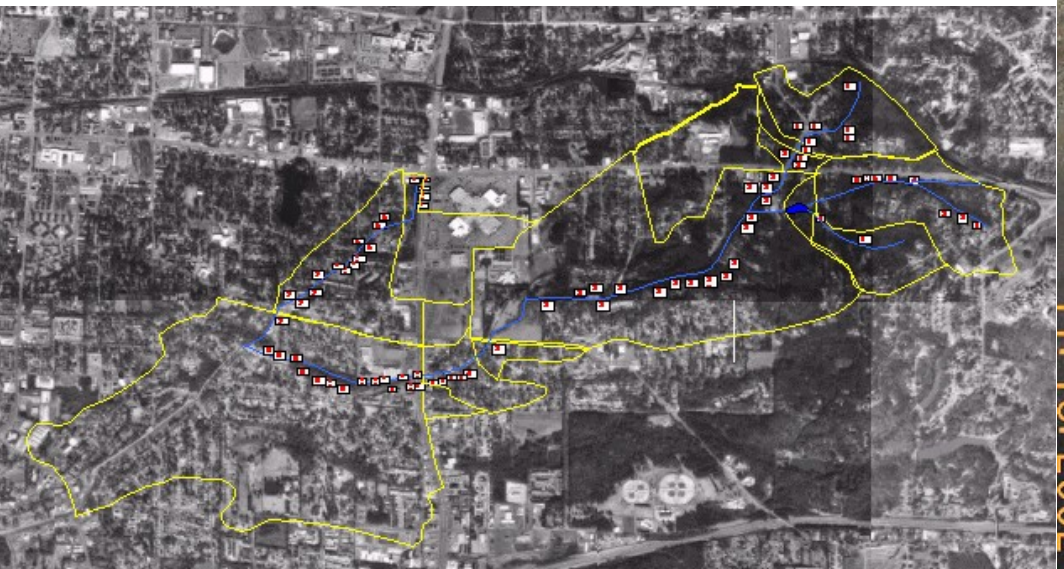
CENTER FOR WATERSHED PROTECTION

IDDE Monitoring Framework

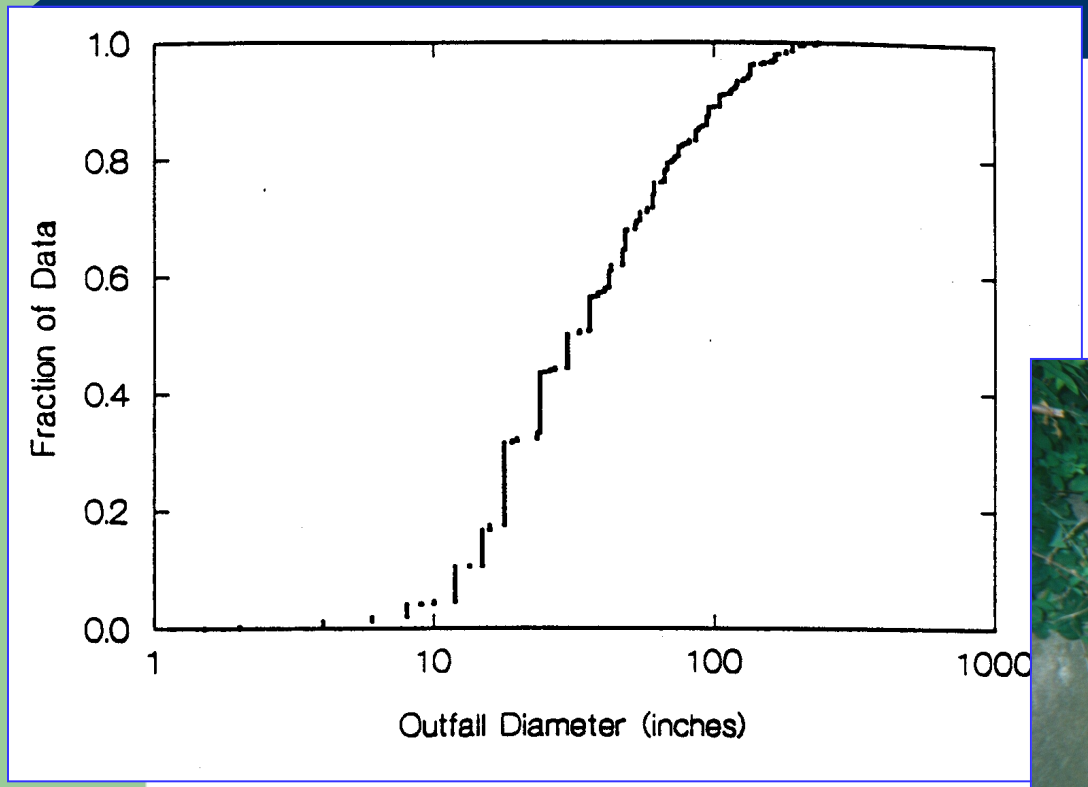


Outfall Reconnaissance Inventory (ORI)
Map, Mark & Photograph Outfalls

- Assign unique ID to each outfall
- Physically mark each outfall
- Use a GPS unit to record outfall locations
- Take a photograph



Small Outfalls Are Important



Small outfalls (<36”) represent 50% of outfalls in

6” Drain in Lewisburg, TN

CENTER FOR WATERSHED PROTECTION

May need to work back up floodplain to find outfall

FOR WATERSHED PROTECTION

Outfall Reconnaissance Inventory (ORI)
Record Basic Characteristics

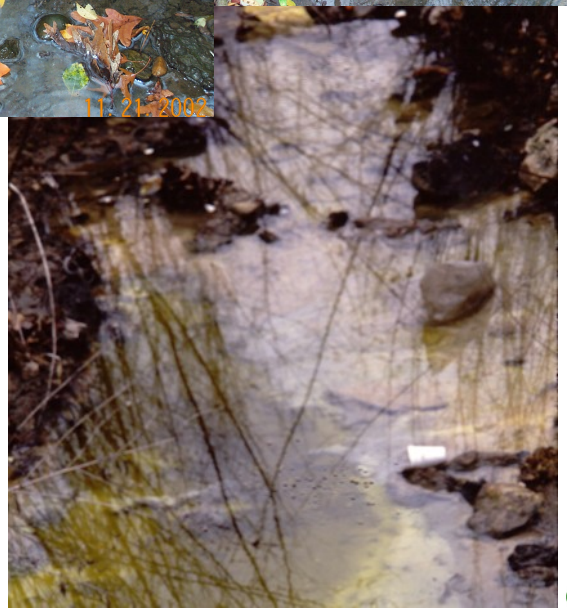
- Dimensions
- Material
- Whether or not outfall flowing

Center for Watershed Protection

Outfall Reconnaissance Inventory (ORI)

Physical Indicators

- Odor
- Color
- Turbidity
- Floatables
- Deposits/Stains
- Vegetation
- Pipe Benthic Growth



CENTER FOR WATERSHED PROTECTION

Outfall Reconnaissance Inventory (ORI)

Simple Monitoring at Flowing Outfalls

- pH
- Temperature
- Ammonia

CENTER FOR WATERSHED PROTECTION

Outfall Reconnaissance Inventory (ORI)

- Take flow sample at outfalls with likely problems
- Deal with major problems immediately

Photo Source: R. Frymire

CENTER FOR WATERSHED PROTECTION

OUTFALL RECONNAISSANCE INVESTIGATION/ SAMPLE COLLECTION FIELD SHEET

SECTION 1. BACKGROUND DATA

SUBWATERSHED:		OUTFALL ID:	
TODAY'S DATE:		TIME (MIL):	
INVESTIGATORS:		FORM COMPLETED BY:	
AIR TEMP. (°F):	RAINFALL (IN.): (LAST 24 HOURS)	RAINFALL (IN.): (LAST 48 HOURS)	
LAT:	LONG:	GPS MARK #:	GPS UNIT:
CAMERA:		PHOTO #S:	

LAND USE IN DRAINAGE AREA (CHECK ALL THAT APPLY):

- ☐ INDUSTRIAL
- ☐ ULTRA-URBAN RESIDENTIAL
- ☐ SUBURBAN RESIDENTIAL
- ☐ COMMERCIAL
- ☐ OPEN SPACE
- ☐ INSTITUTIONAL
- OTHER: _____
- KNOWN INDUSTRIES: _____

NOTES (E.G., ORIGIN OF OUTFALL IF KNOWN):

SECTION 2. OUTFALL DESCRIPTION

LOCATION	MATERIAL	SHAPE		DIMENSIONS (IN.)	SUBMERGED
☐ **CLOSED PIPE**	☐ RCP ☐ CMP ☐ PVC ☐ HDPE ☐ STEEL ☐ OTHER: _____	☐ CIRCULAR ☐ ELIPTICAL ☐ BOX ☐ OTHER: _____	☐ SINGLE ☐ DOUBLE ☐ TRIPLE ☐ OTHER: _____	DIAMETER/ DIMENSIONS: _____	IN WATER: ☐ NO ☐ PARTIALLY ☐ FULLY WITH SEDIMENT: ☐ NO ☐ PARTIALLY ☐ FULLY
☐ **OPEN DRAINAGE**	☐ CONCRETE ☐ EARTHEN ☐ RIP-RAP ☐ OTHER: _____	☐ TRAPEZOID ☐ PARABOLIC ☐ OTHER: _____		DEPTH: _____ TOP WIDTH: _____ BOTTOM WIDTH: _____	
☐ **IN-STREAM**	**(APPLICABLE WHEN COLLECTING SAMPLES)**				
FLOW PRESENT?	☐ YES ☐ NO	***IF NO, SKIP TO SECTION 5***			
FLOW DESCRIPTION (IF PRESENT)	☐ TRICKLE ☐ MODERATE ☐ SUBSTANTIAL				

SECTION 3. QUANTITATIVE CHARACTERIZATION

FIELD DATA FOR FLOWING OUTFALLS				
PARAMETER		**RESULT**	**UNIT**	**EQUIPMENT**
☐FLOW #1	VOLUME		LITER	BOTTLE
	TIME TO FILL		S	
☐FLOW #2	FLOW DEPTH		IN	TAPE MEASURE
	FLOW WIDTH	_____' _____"	FT, IN	TAPE MEASURE
	MEASURED LENGTH	_____' _____"	FT, IN	TAPE MEASURE
	TIME OF TRAVEL		S	STOP WATCH
TEMPERATURE			°F	THERMOMETER
pH			pH UNITS	TEST STRIP
AMMONIA			mg/L	TEST STRIP

Outfall Reconnaissance Investigation Field Sheet

Section 4. Physical Indicators for Flowing Outfalls Only

Are Any Physical Indicators Present in the Flow? ☐ Yes ☐ No *(If No, Skip to Section 5)*

Indicator	Check if Present	Description	Relative Severity Index (1-3)		
Odor	☐	☐ Sewage ☐ Rancid/Sour ☐ Petroleum/Gas ☐ Sulfide ☐ Other: _____	☐ 1 – Faint	☐ 2 – Easily detected	☐ 3 – Noticeable from a distance
Color	☐	☐ Clear ☐ Brown ☐ Grey ☐ Yellow ☐ Green ☐ Orange ☐ Red ☐ Other: _____	☐ 1 – Faint colors in sample bottle	☐ 2 – Clearly visible in sample bottle	☐ 3 – Clearly visible in outfall flow
Turbidity	☐	See Severity	☐ 1 – Slight cloudiness	☐ 2 – Cloudy	☐ 3 – Opaque
Floatables -Does not include trash!!	☐	☐ Sewage (Toilet Paper, etc.) ☐ Petroleum (oil sheen) ☐ Other: _____	☐ 1 – Few/slight; origin not obvious	☐ 2 – Some; indications of origin (e.g., possible suds or oil sheen)	☐ 3 - Some; origin clear (e.g., obvious oil sheen, suds, or floating sanitary materials)

Section 5. Physical Indicators for Both Flowing and Non-Flowing Outfalls

Are physical Indicators not related to flow Present? ☐ Yes ☐ No *(If No, Skip to Section 6)*

Indicator	Check if Present	Description	Comments
Outfall Damage	☐	☐ Spalling, Cracking or Chipping ☐ Peeling Paint ☐ Corrosion	
Deposits/Stains	☐	☐ Oily ☐ Flow Line ☐ Paint ☐ Other: _____	
Abnormal Vegetation	☐	☐ Excessive ☐ Inhibited	
Poor Pool Quality	☐	☐ Odors ☐ Colors ☐ Floatables ☐ Oil Sheen ☐ Suds ☐ Excessive Algae ☐ Other: _____	
Pipe Benthic Growth	☐	☐ Brown ☐ Orange ☐ Green ☐ Other: _____	

Section 6. Overall Outfall Characterization

☐ **No indication of illicit discharges** ☐ **Some likelihood of illicit discharge (i.e, presence of 2 or more indicators)** ☐ **Almost certain a discharge exists (i.e, 1 or more indicator with a severity of 3)**

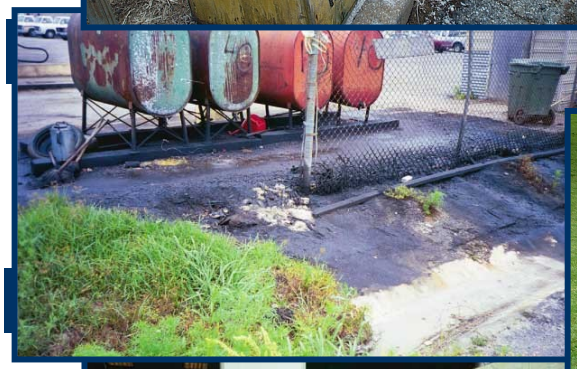
Section 7. Data Collection

1. Sample For The Lab? ☐ Yes ☐ No
2. If Yes, Collected From: ☐ Flow ☐ Pool
3. OBM Trap Set? ☐ Yes ☐ No

Section 8. Any non-Illicit Discharge Concerns (e.g., trash or needed infrastructure repairs)?

Land Use & Potential Generating

- Residential
- Commercial
- Industrial
- Institutional
- Municipal

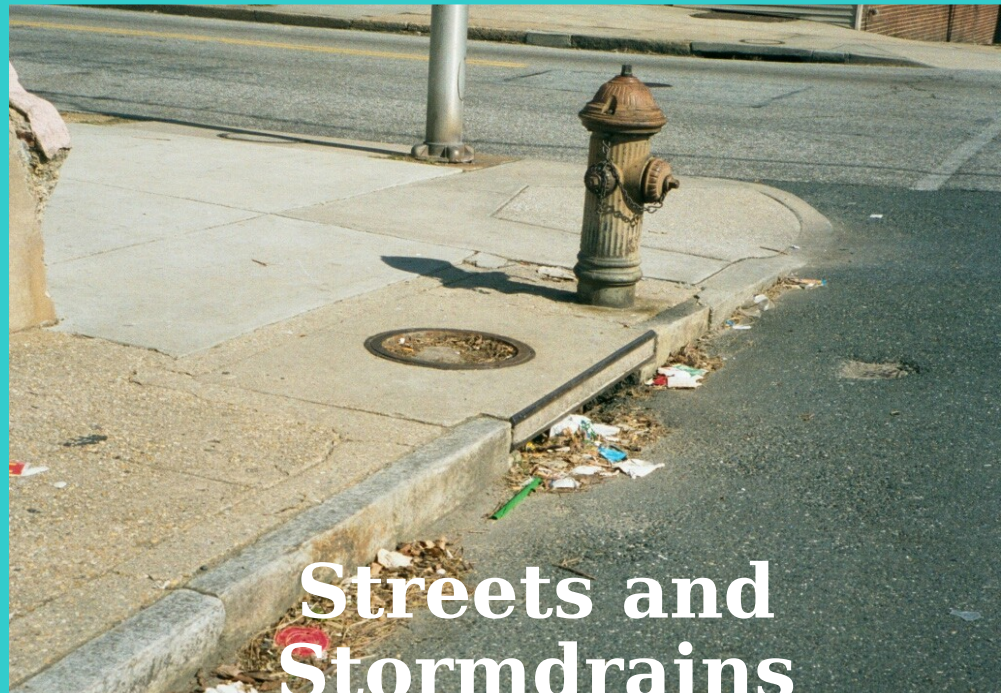


CENTER FOR WATERSHED PROTECTION

Neighborhood Source Assessment

Hotspot Site Investigation

Pervious Area Assessment



Streets and Stormdrains

Hotspot Site Investigation

- Site Data and Basic Classification
- Vehicle Operations
- Outdoor Material
- Waste Management
- Physical Plant
- Turf / Landscaping Areas
- Stormwater Infrastructure

Center for Watershed Protection

Hotspot Site Investigation, cont.
Outdoor Materials

C. Outdoor Materials ☐ N/A *(Skip to part D)*	Observed Pollution Source?
C1. Are loading/unloading operations present? ☐ Y ☐ N ☐ Can't Tell If yes, are they uncovered *and* draining towards a storm drain inlet? ☐ Y ☐ N ☐ Can't Tell	○
C2. Are materials stored outside? ☐ Y ☐ N ☐ Can't Tell If yes, are they ☐ Liquid ☐ Solid Description: _____ Where are they stored? ☐ grass/dirt area ☐ concrete/asphalt ☐ bermed area	○
C3. Is the storage area directly or indirectly connected to storm drain (circle one)? ☐ Y ☐ N ☐ Can't Tell	○
C4. Is staining or discoloration around the area visible? ☐ Y ☐ N ☐ Can't Tell	○
C5. Does outdoor storage area lack a cover? ☐ Y ☐ N ☐ Can't Tell	○
C6. Are liquid materials stored without secondary containment? ☐ Y ☐ N ☐ Can't Tell	○
C7. Are storage containers missing labels or in poor condition (rusting)? ☐ Y ☐ N ☐ Can't Tell	○

Center for Watershed Protection

What the ORI Cannot Do

- Misses a significant number of discharges, and can sometimes lead to a “false positive” as well (Pitt, 2001)
- Detect intermittent flows that leave no trace
- Quantify impacts definitively (no direct measure of relative problem)
- Define sources (except for some obvious indicators)

CENTER FOR WATERSHED PROTECTION

Quick and Dirty ORI Exercise

(Pardon the pun!)

Center for Watershed Protection

Look at each photo and answer the following:

1. Is the outfall a closed pipe or open drainage?
2. What material is the pipe made of?
   - (RCP, CMP, PVC, HDPE, Steel, Other?)
3. Is there flow present?
4. What is the color of the flow?
5. Are floatables present? If so, what kind?
6. Is there any outfall damage?
7. Are there any deposits or stains?
8. Is there any abnormal vegetation in or around the outfall?
9. Should a water sample be collected at this outfall?
10. Do you see anything else?

CENTER FOR WATERSHED PROTECTION

Source: Fort Worth DEM

CENTER FOR WATERSHED PROTECTION

Source: R. Frymire

IL-75

121

Post-Screening Prioritization

ORI, combined with other existing data, can help determine:

- Extent of the problem
- If problems are “clustered”
- Indicators of intermittent discharges
- Relative ranking of problem outfalls

Center for Watershed Protection

Factors to Consider

- Fraction flowing (from ORI)
- Number with physical indicators, and severity
- Indicators at dry outfalls
- Other existing monitoring data
- In-stream goals
- History of complaints

Center for Watershed Protection

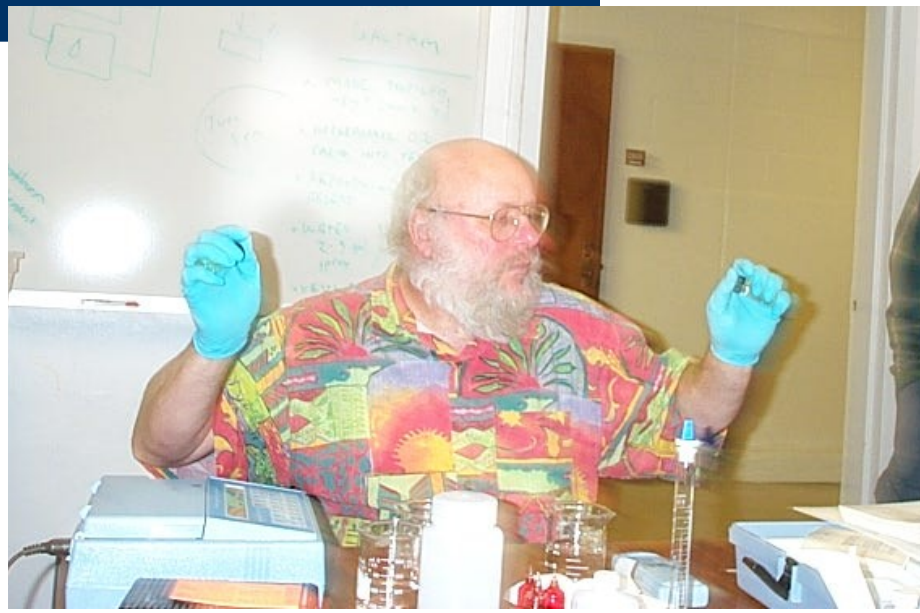
Detailed Field Sampling / Lab Analysis

- More detailed sampling that includes:
  - Sampling to ID problem outfalls not apparent from physical indicators alone
  - Source identification
  - Potential intermittent monitoring

Center for Watershed Protection

Forensics

- Run chemical tests
- Choose specific indicators depending on local “fingerprints” or based on land use in area



Center for Watershed Protection

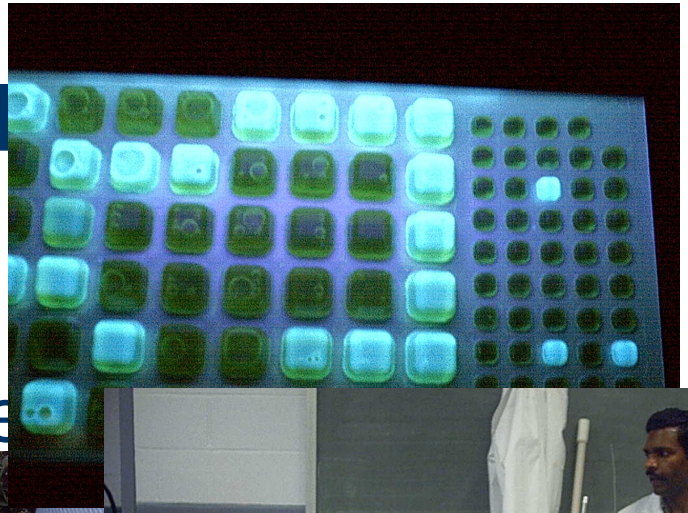
Key Features for Ideal Indicators

- Distinguishes a particular source
- “Tight” statistical distribution
- Precise measurement
- Safe
- Relatively inexpensive
- Simple to conduct

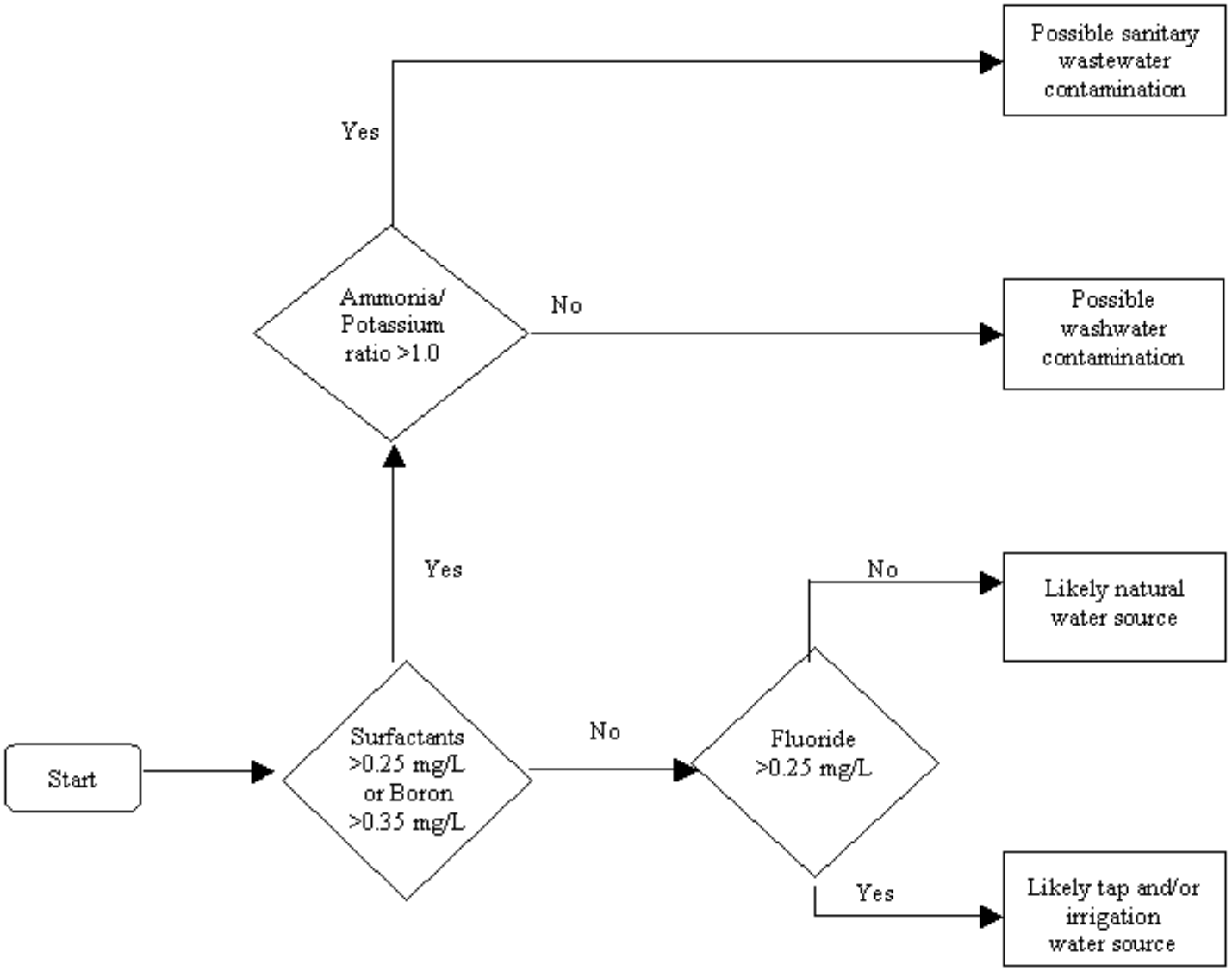
Center for Watershed Protection

Key Lab Considerations

- Equipment cost
- Staff training
- Number of sample
- Safety
- Disposal



Flow Chart to Identify Illicit Discharges in Residential Drainage Areas



Benchmark Concentrations to Identify Industrial Discharges

Benchmark	Concentration	Notes
Ammonia (mg/L)	**□50**	• Existing “Flow Chart” Parameter • Concentrations higher than the benchmark can identify a few industrial discharges
Potassium (mg/L)	**□20**	• Existing “Flow Chart” Parameter • Excellent indicator of a broad range of industrial discharges
Color (Units)	**□500**	• Supplemental parameter that identifies a few specific industrial discharges
Conductivity (□S/cm)	**□2,000**	• Identifies a few industrial discharges • May be useful to distinguish between industrial sources
Hardness (mg/L as $CaCO_3$)	**□10** **□2,000**	• Identifies a few industrial discharges • May be useful to distinguish between industrial sources
pH (Units)	**□5**	• Only captures a few industrial discharges • High pH values may also indicate an industrial discharge but residential wash waters can have a high pH as well

Chemical Fingerprint Library

- Shallow Groundwater
- Spring Water
- Tap water
- Irrigation
- Sewage
- Septic Tank Discharge
- Common Industrial Discharges
- Commercial Car Wash
- Commercial Laundry

CENTER FOR WATERSHED PROTECTION

Fingerprints of Major Sources

Sewage

- E. Coli
- Detergents (various)
- High Ammonia/ Potassium Ratio

Wash Water

- Detergents (various)

Shallow Groundwater

- Hardness, pH

Tap Water

- Fluoride
- Sometimes Hardness

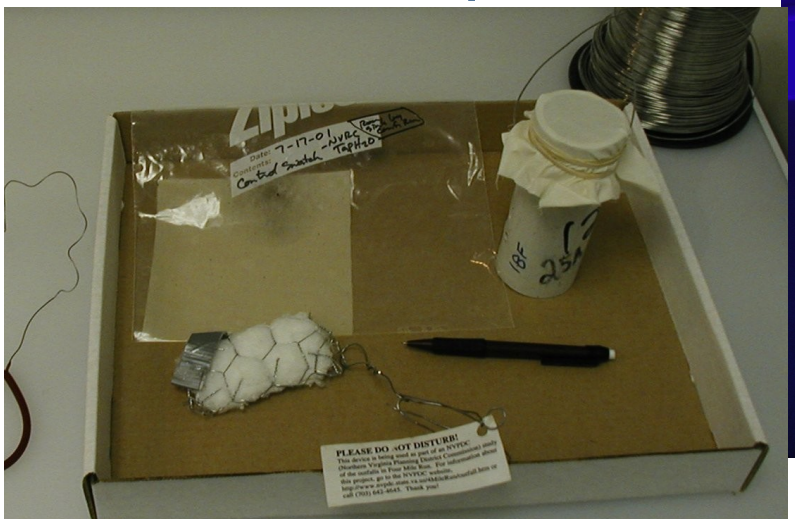
Septage

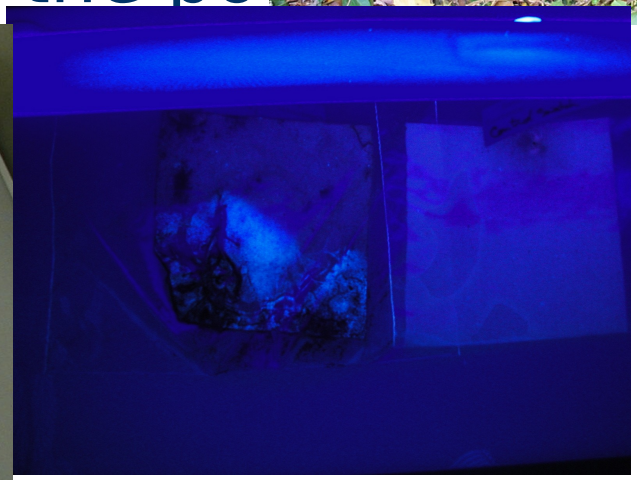
- E. Coli
- Fluorescence
- High Ammonia/Potassium

CENTER FOR WATERSHED PROTECTION

Special Indicators for Intermittent Discharges

- Optical brightener monitor
- Toxicity testing
- Outfall damming
- Take a sample from the po





CENTER FOR WATERSHED PROTECTION

Finding and Fixing

- Move up the pipe
- Use smoke or dye testing once narrowed
- Use enforcement or

Center for Watershed Protection

Most Wanted List

- Look up reference for common types of illicit discharges (e.g., sewage, wash water, spills)
- General overview of indicators, detection methods, source tracing, removal, and prevention
- Possible case study approach

CENTER FOR WATERSHED PROTECTION

Most Wanted List

IDDE How To Problem Solver Matrix				
Type	**Detect**	**Trace back to a source**	**Remove**	**Prevent**
Sewage: Ammonia, Detergent, E. Coli best chemical tracers; Odor, turbidity, floatable materials best physical indicators				
Break in the Right of Way	• Outfall sampling • Hotline • In-stream data	• Trunk investigations	Repair by municipality	Sewer System rehabilitation
Direct connection: commercial or industrial	• Outfall sampling • Hotline • In-stream data • Roving dye test	• Trunk investigations, including dye test	Enforcement	• Plumbing code • Building inspection
Direct connection: residential	• Outfall sampling • Hotline • In-stream data	• Trunk investigations • Smoke or dye	• Enforcement • Incentive or aid?	
Infrequent discharge, such as RV dumping	• Hotline: in-stream • Hotline: upland • In-stream if daily • Intermittent analyses	• Trunk investigations	• Make them stop (smack down) • Spill response	• Education • Presence in the watershed • Fines
Straight Pipes/ Septic	• In-stream data • Hotline • Time of sale inspections	• In-stream data/ hotline: stream walk • Inspections: known	• Enforcement • Incentive or aid?	• Septic maintenance program • Education • Good septic design guidelines

Most Wanted List Cont'd

IDDE How To Problem Solver Matrix				
Type	**Detect**	**Trace back to a source**	**Remove**	**Prevent**
Wash water: Detergents best chemical tracer Suds, odor best physical indicators				
Direct connection: commercial or industrial	• Outfall sampling • Hotline • In-stream data • Intermittent analyses • Roving dye test	• Trunk investigations, dye test • Likely need intermittent	• Enforcement	• Plumbing code • Building inspection • Fines: plumbing contractors
Direct connection: residential	• Outfall sampling • Hotline • Intermittent analyses	• Trunk investigations, Smoke or dye	• Enforcement	• Plumbing code • Building inspection • Fines: plumbing contractor • Education: do-it-yourselfers
Power wash/ car wash (commercial operators) Commercial Wash Down (other)	• Hotline: upland • Intermittent analyses	• Through hotline	• Enforcement	• Training and education • Fines • NPDES permit • Presence in the watershed
Residential car wash	• USSR • Intermittent analyses	• Direct observation	Ask them to stop	• Education

Most Wanted List Cont'd

IDDE How To Problem Solver Matrix				
Type	**Detect**	**Trace back to a source**	**Remove**	**Prevent**
Oils/ Solvents: Oil sheen/ oil stains/petroleum odor best indicators				
Professional oil change/ car maintenance	• Hotline: upland and at outfall • Toxicity/ intermittent analyses	• Upland ID: known • Land use analysis if outfall	• Enforcement • Spill response	• Fine structure • Education/ training • Presence in the watershed • NPDES • Inspection permit
Dumping: Heating oil/ solvents	• Hotline: upland and at outfall	• Upland ID: known • Outfall: try to find immediately		• Fines • Presence in the watershed
Homeowner oil change	• Hotline: upland and at outfall	• Upland ID: known • Trunk investigation	• Warning/ information • Fines	• Education • Hazardous waste pickup • Fines • Presence in the watershed
Spill (trucking)	• Hotline	• Upland ID: known • Outfall: try to find immediately	• Spill response	• Fine structure • Education/ training

What could you do if……

- There are minimal illicit discharge problems anticipated throughout the MS4.

CENTER FOR WATERSHED PROTECTION

What could you do if…

- The anticipated problems are confined to a few subwatersheds or reaches, where history of suspect discharges exist or in-stream dry weather water quality is consistently poor.

Center for Watershed Protection

What could you do if……

- The community has chronic dumping areas.

CENTER FOR WATERSHED PROTECTION

What could you do if……

- Anticipated problems are confined to areas with high densities of generating sites.

Center for Watershed Protection

What could you do if……

- Community used to be on combined sewer system or existing sanitary sewer infrastructure is old & has history of problems .

CENTER FOR WATERSHED PROTECTION

What could you do if……

- Community has old development areas (i.e., > 20 years) with high density of septic systems.

Center for Watershed Protection

What could you do if……

- Significant illicit discharges are suspected throughout jurisdiction & across all land uses.

CENTER FOR WATERSHED PROTECTION